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Context and learner modelling for the mobile foreign language learner ☆

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Abstract

Given the growing use of mobile devices, there is now increasing interest in the potential for supporting the mobile learner. However, there remains much research to be undertaken, to find effective ways of facilitating learning with mobile devices. This paper considers how to support the mobile language learner using a handheld computer. It introduces TenseITS, a language learning environment that adapts the interaction to the individual learner's understanding, as represented in a learner model constructed during the interaction. It also adapts according to contextual features of the learner's location that may affect their ability to study – the likelihood that they will be interrupted by others; their general ability to concentrate at that location; and the amount of time they have available for study.

Keywords: Mobile learning; Handheld computer; Learner modelling; Location and context; Explicit knowledge

☆ Editor's note: Although this paper does not strictly speaking describe evaluated research, we feel that its considerable interest as a new field of educational technology justifies its inclusion in *System*.

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1. Introduction

Intelligent tutoring systems (ITS) build a model of the individual learner's knowledge, difficulties and misconceptions, as they interact with the system. This learner model can be compared with a model of the target domain to enable suitable tutorial strategies to be inferred by the system, as appropriate for the learner according to the contents of their learner model – i.e., the educational interaction is tailored to the specific learning needs of the individual student.

Most ITSs are designed for use on standard desktop computers or laptops, and it is assumed that the user will be using the environment in a single location, or a similar set of locations. It also tends to be assumed that the user will have time to devote to the learning tasks, and that they will be able to concentrate on their learning.

With increasing use of handheld computers, educational environments have been developed for use on these devices. However, relatively few systems have attempted to model the user's understanding. Examples include Ketamo's (2002) Adaptive Geometry Game, which adapts polygon recognition questions according to a child's accuracy and speed of response to multiple choice questions; Bull and McEvoy's (2003) C-POLMILE, which adapts the interaction according to university students' performance in multiple choice questions in the C programming domain; and Malliou et al. (2002) proposed user profile to enable the creation of personalised courses through the combination of modules into a personalised virtual document. Such approaches are similar to the standard systems available for use on desktop PCs.

Other environments take the user's location or some aspect of the general context into account, to enable presentation of information or provision of an interaction that is relevant to the learner's situation. Dey and Abowd (1999) define context-awareness as 'the use of context to provide task-relevant information and/or services to a user, wherever they may be'. An educational example is Zancanaro et al.'s (2003) museum guide. This uses infrared sensors to detect the user's location, and presents multimedia information related to the fresco painting in front of which the user is standing. Such approaches aim to offer information or interactions that are relevant to the interests of the user, as inferred from the fact that they have chosen to view certain objects. However, beyond adapting to the user's interests, this kind of approach does not usually adapt to other attributes of the individual (such as their existing knowledge about the painting, the artist or the period).

Jameson (2001) argues for a need to combine research in the areas of user modelling and context-awareness. An example of such an approach is the LISTEN system (Zimmerman et al., 2003), which offers audio presentations to a visitor to an art exhibition, according to their location and also their profile. A language learning example is Ogata and Yano's (2004) system, which models the learner's comprehension of Japanese polite expressions, and personal attributes (e.g., age). Depending on the room the learner is in (e.g., meeting room, office), the system will prompt with expressions using the right level of formality for the location and participants (who will also have entered their personal information to their profiles).

The above examples relate to situations where the task and location are connected. However, there are also uses for location-aware, individually adaptive learning environments where the task is not related to the location of the user. It would be useful to have a mobile learning environment that not only adapts to the individual's specific learning needs according to their current knowledge state (as is standard in ITSs used on desktop PCs), but also with reference to their location – specifically features of that location that may influence their learning requirements, such as how likely they are to be interrupted or distracted by others in that location, and how able they are to focus or concentrate on the task more generally. As also argued by Becking et al. (2004), in addition to concentration and related issues, also relevant to such a mobile ITS is the time learners will have available to devote to the task, as sometimes they may have only a very short period of time, whereas other times they may have more time. This paper presents such a system: TenseITS, a mobile intelligent tutoring system for the use of tense in English, designed primarily for Chinese learners of English.

In addition to individual differences, Chinese learners of English tend to have typical problems with English, which include the correct use of tense as time is expressed differently in Chinese (Chang, 1987; Dalgish, 1984). ITSs that take account of language transfer – the influence of other languages on a learner's acquisition of the target language (see Odlin, 1989) – have been developed for a long time (e.g., Bull, 1995; Catt and Hirst, 1990; Schuster, 1986; Schwind, 1990; Wang and Garigliano, 1995; Weischedel et al., 1978). As described above, work is now being undertaken on adaptively supporting the mobile foreign language learner (Ogata and Yano, 2004). Mobile approaches for handheld computers that do not adapt to context or users are also being developed, for example: vocabulary for a variety of languages (ECTACO, not dated); video-based learning objects for American Sign Language (Lehman and Conceicao, 2003).

TenseITS allows the mobile language learner to make use of individualised learning opportunities that would otherwise not be available to them. It aims to fit around their daily routine, without disrupting other activities. This would be particularly useful, for example, for the busy user wishing to improve their English before a business or other trip abroad; or upon arrival, perhaps by a tourist or a student beginning a new course. TenseITS allows the learner to learn while on the bus, while waiting for friends at a restaurant, while waiting for an appointment, for the brief period of time between lectures, etc. This accords with Sharples (2000) view that learners should be enabled to learn at times and locations of their choice. A logbook study (Bull, 2003) found that our initial target users (see below), will indeed use handheld computers in a variety of locations, ranging from home and the university, to restaurants and pubs, to public transport, and even in bed.

TenseITS is, at this stage, a relatively simple intelligent tutoring system, developed sufficiently to demonstrate the potential of this approach to supporting the mobile learner using a handheld computer. We focus initially on Chinese MSc students, as our target learners often perceive a need to continue their study of English throughout their degree (unpublished survey data). As is often the case with intelligent tutoring systems, currently the domain is quite restricted. Ultimately we wish to extend the domain beyond tenses, and to also consider learners with other language backgrounds, and implementations for other languages.

2. Requirements of a context-aware, learner modelling system for the mobile learner

As stated above, conventional ITSs are usually designed for use on desktop PCs. A method of supporting today's increasingly mobile learner is required. Combining ITS and mobile learning technology offers a solution. Advantages of a mobile intelligent tutoring system are that it is:

1. *individualised according to the learner's knowledge*, as in a standard ITS: i.e., the system will adapt to the learner's abilities, knowledge, difficulties and misconceptions;
2. *individualised according to the learner's location and needs in that location:* unlike many location-aware environments that adapt the interaction according to features of the location, a mobile ITS must take into account features of the location that may affect the individual user's learning;
3. *portable:* most obviously, a mobile ITS must be usable in a variety of locations, as required by the user – hence the use of a handheld computer.

The following scenario illustrates our system with reference to the above points:

Tracy is a Chinese student in the department of Electronic, Electrical and Computer Engineering at the University of Birmingham, UK. Her degree requires an ability to write good academic English, for example, in her final project report. Tracy takes every opportunity to improve her English grammar, as this is the area in which she needs most practice.

Tracy has just come out of a lecture. She is now waiting for a friend in the common room, located in the department building. Her friend's lecture was on the other side of campus. Therefore, Tracy has about 20 min to spare before her friend will arrive. She wants to use this time productively, but the time is a little short to go to the computer laboratory to log onto her account. She therefore takes out her iPAQ and runs TenseITS. On the context screen, she selects the option indicating that she is in the common room (one of the locations she added to the system herself). Her usual values for concentration level and frequency of interruption, for that location, are shown: medium and high, respectively. However, today there are not very many people about, so she alters the frequency of interruption to low. She selects that she has between 15 min and half an hour for her interaction. The system already knows her strengths and weaknesses, based on her previous interactions. She has completed previous exercises successfully, so the system recommends a new topic to look at, followed by a short series of questions. She spends 15 min on the tutorial, and then begins to answer the questions. At that point her friend arrives and she ends her interaction, in the knowledge that her learner model will be updated, and the next time she starts TenseITS she will be able to resume the exercise or receive a new recommendation, appropriate for her location and available time, on that occasion.

The requirements for the system to operate as described above, are as follows:

- multiple context inputs: location information and amount of available time;
- individual learner model;

- adaptive and individualised learning materials;
- appropriate interactions for varying periods of time;

where:

1. location information includes the user's current location, concentration level and frequency of interruption at that location;
2. the system can infer either default values of concentration level and frequency of interruption according to the specific location, or typical properties that the user has identified in that location;
3. the learner model contains the user's current knowledge level, difficulties and misconceptions;
4. the learner model is constructed according to the user's interactions with the learning materials;
5. inferences of location information, the amount of available time and the learner model contents, can generate appropriate learning interactions for the individual.

The following section describes TenseITS in greater detail.

3. TenseITS: adapting to learner knowledge, location and contextual features

As stated above, the domain of TenseITS is the use of tense in English; the material and exercises designed in particular for Chinese learners of English. The key learner model attributes are: *knowledge*, *difficulties*, *misconceptions*; augmented by contextual information about *location*, *interruption/distraction*, *concentration*, *available time*.

TenseITS infers a user's understanding of the domain based on their responses to multiple choice questions, representing this understanding in the learner model. This is as occurs in many standard ITSs. Multiple choice questions are used because of the ease with which the input can be made in comparison with other methods, when using a handheld device. The system models the learner's knowledge (i.e., what they know – e.g., *the present perfect is used with expressions relating to completed time*). Their lack of knowledge is inferred from an absence of data about a concept or topic in the learner model. Difficulties are inferred from the number of incorrect responses for a question type. Misconceptions (e.g., *the present tense always refers to present time*) are modelled, inferred by matching a set of incorrect responses to data in a misconceptions library.

Users state their location by menu selection, at the start of an interaction. This is illustrated in Fig. 1. (Users can add their own locations to those provided in the default list.) Appropriate content or exercises are then selected according to both the learner's knowledge state and their context, as in the examples in Fig. 2 (tutorial), 3 (exercise) and 4 (revision and learner model).

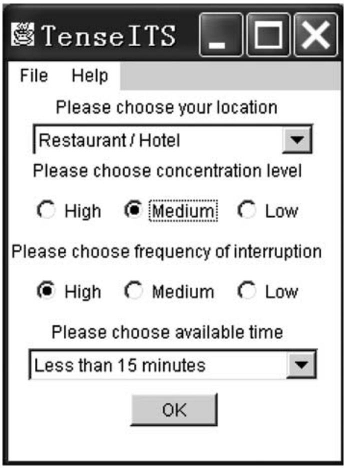

Fig. 1. Selecting location and contextual features of that location.

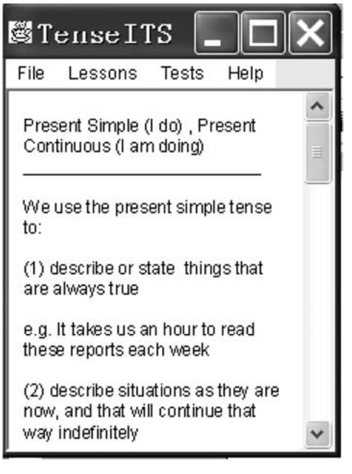

Fig. 2. Excerpt from a tutorial.

The explanations (Fig. 2) and exercises (Fig. 3) look similar to standard interactions although, as stated above, they are selected as appropriate for the individual's current learning needs. Revision material is integrated explicitly with the learner model data (Fig. 4). This in particular illustrates how the interaction is adapted to the learner's current understanding. In this example the system has inferred a possible misconception. This is pointed out to the student (paragraph 1 in Fig. 4), as they may not otherwise have been aware of the existence of the misconception (e.g., perhaps realising a difficulty, but not appreciating that their problems are due to an underlying misconception). The explanation takes the individual's misconception as a start-

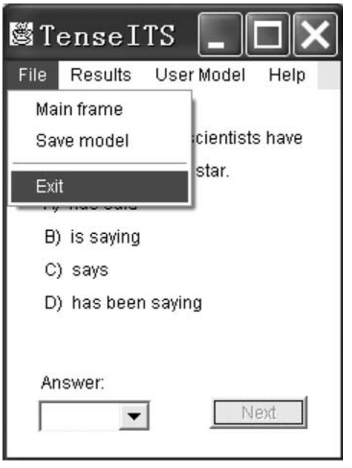

Fig. 3. Excerpt from an exercise (also illustrating the ability to swap activity at any time).

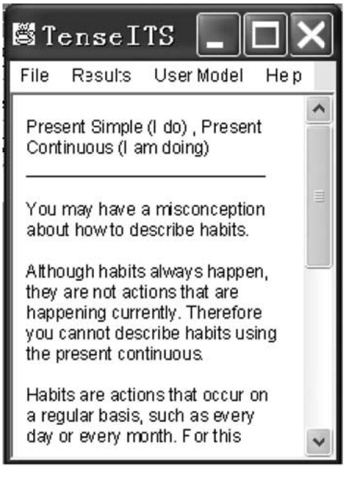

Fig. 4. Excerpt from revision material and the learner model.

ing point (paragraph 2 in Fig. 4), before giving the standard explanation (paragraph 3 of Fig. 4). This approach to presenting material should help a learner to notice features of the language of which they had been unaware, when they next encounter them. 'Noticing' (Schmidt, 1990) and awareness-raising or consciousness-raising (Rutherford and Sharwood Smith, 1985) have been argued as useful in foreign language learning, as explicit knowledge can help facilitate acquisition. It can prepare learners for language features, and provide knowledge against which they can compare their own output. This may be especially useful for those learners who favour metacognitive language learning strategies which involve explicit knowledge of the learning process, planning, monitoring and self-evaluation (see O'Malley and Chamot, 1990; Oxford, 1990), and are amongst the strategies sometimes used by Chinese students (Bedell and Oxford, 1996).

The logbook study of handheld computer use (Bull, 2003), while not discovering general usage patterns in different locations, found consistent individual patterns. It is therefore not desirable that the learner should always have to provide the same information each time they use TenseITS in a particular location, if the features associated with that location are constant. Thus, the system infers the appropriate context information based on the user's choices over time, and offers these as pre-selected default choices, for the user to change only if necessary. The system starts with a set of default values for each of the default locations (in cases where the user has not changed the values). These values are then updated to reflect the individual's choices as they use the system. Table 1 shows the default values. Concentration level and frequency of interruption have the following three options: H – High, M – Medium and L – Low.

Using C for 'Concentration level', F for 'Frequency of interruption', and H for 'High', M for 'Medium' and L for 'Low', the labels for Table 2 are obtained. Thus, CH means that the concentration level is high; CM indicates a medium level of concentration; and CL a low concentration level. Similarly, FH specifies that the frequency of interruption is high; FM, medium; and FL, low. Table 2 shows the parameter Lo, which indicates the location model, generated from the values of concentration level and frequency of interruption.

There are four options for available time: less than 15 min, between 15 and 30 min, between 30 min and 1 h, and more than 1 h. TenseITS was designed primarily for use for short periods of time (up to 30 min), but the other options are available as there may be occasions in which the learner wishes to use the system for longer (and indeed, some students did report using TenseITS for longer periods). The parameter

Table 1
Default location values for concentration and likelihood of interruption

	Concentration level	Frequency of interruption
Restaurant	M	H
Station	L	H
Vehicle	L	M
Outing	M	M
Home	H	L
Campus	H	L

Table 2
The value of parameter Lo (location)

	CH	CM	CL
FL	Lo = 1	Lo = 2	Lo = 2
FM	Lo = 2	Lo = 3	Lo = 3
FH	Lo = 2	Lo = 3	Lo = 4

T stands for the available time, so that T has the four corresponding values: $T=1$, $T=2$, $T=3$ and $T=4$. Therefore, the final parameter context model can be generated from the parameter T and the parameter Lo. This is illustrated in Table 3.

The system will provide the user with appropriate interactions based on his/her current context model integrated with the learner model information (knowledge, difficulties and misconceptions). Table 4 gives some interaction examples.

Model 1 applies with any location conditions where the learner has at least an hour; or where they have between 30 min and an hour in which they can concentrate and are unlikely to be interrupted. With Model 1, an interaction similar to that with a standard intelligent learning environment will be offered. This may include tutorials, exercises relating to those tutorials, revision of material learnt – selected according to the student's needs as represented in their learner model.

Model 2 applies in situations where the learner has between 15 and 30 min, where they can concentrate and are unlikely to be interrupted; or where they have between 30 min and an hour, have a high level of concentration and either a medium or high frequency of interruption; or between 30 min and an hour with a medium or low level of concentration, but low level of interruption. Here, the learner is offered a tutorial on a single topic followed by an exercise on that topic.

Model 3 is used in cases where learners have between 15 and 30 min available, have a high level of concentration and either a medium or high likelihood of interruption; or when they have 15–30 min with a low frequency of interruption and medium or low levels of concentration; or if they have between 30 min and an hour

Table 3
The value of parameter model

	Lo = 1	Lo = 2	Lo = 3	Lo = 4
$T=4$ (60+)	Model = 1	Model = 1	Model = 1	Model = 1
$T=3$ (30–60)	Model = 1	Model = 2	Model = 3	Model = 4
$T=2$ (15–30)	Model = 2	Model = 3	Model = 4	Model = 5
$T=1$ (15−)	Model = 6	Model = 6	Model = 7	Model = 7

Table 4
Example of interactions in TenseITS

Conditions (context model + user model)	Interactions (recommended options by the system)
Model = 1	Normal study (tutorials, exercises, revision)
Model = 2	One topic tutorial with full exercise
Model = 3	One topic tutorial with short exercise
Model = 4	One topic tutorial
Model = 5 & user has not viewed content before	One topic tutorial
Model = 5 & user has viewed content before	Revision of topic tutorial
Model = 6 & user has not completed exercise before	One topic tutorial
Model = 6 & user has completed exercise before	Revision of exercise (full exercise)
Model = 7 & user has not completed exercise before	One topic tutorial
Model = 7 & user has completed exercise before	Revision of exercise (short exercise)

Note: tutorials are also adapted to the user's knowledge state.

with medium concentration levels and medium or high levels of interruption; or between 30 min and an hour with medium likelihood of interruption and medium level of concentration. Model 3 recommends a tutorial on a single topic followed by a short exercise about that topic.

Model 4 applies if a student has 15–30 min, medium concentration and medium or high levels of interruption; or 15–30 min with a low level of concentration and medium level of likely interruption; or if the learner has between 30 min and an hour with a high frequency of interruption and a low level of concentration. In these cases the learner is offered a tutorial.

For Model 5, applicable when learners have 15–30 min to study and a high degree of interruption and a low level of concentration, if a student has not previously covered the most appropriate material with reference to their current understanding, and they have not previously consulted those materials, learners are also offered a single tutorial. If they have covered the relevant material, they will be offered revision materials on that topic.

Model 6 applies if the learner has less than 15 min, has a low level of interruption and any level of concentration; or less than 15 min with a high level of concentration and any likely level of interruption. In these cases, if the user has not previously completed the most relevant exercise according to their learner model, they will be offered a tutorial on a different relevant topic (as the conditions are not appropriate for completing the exercise that would otherwise be recommended). If they have previously attempted the exercise, they will be invited to continue with additional targeted questions, selected according to their previous responses.

Finally, Model 7 is used when students have less than 15 min and a medium or low level of concentration and medium or high level of interruption. If the learner has not already attempted the next most applicable exercise, they will be offered a tutorial on a new topic (again, due to inadequate conditions for completing the most relevant exercise). However, if the learner has previously tried this exercise, they will receive further individualised questions, based on their previous answers.

If a learner previously ended a session before completion, they are able to continue with that session or topic, as appropriate for their current context.

Thus, TenseITS not only aims to adapt the interaction according to an individual's current knowledge state, as in standard ITSs, but also aims to take account of the user's current context (location, frequency of interruption, level of concentration, available time) in order to provide an interaction which is also appropriate for the mobile learner. In the example given in Fig. 1, where the user is in a restaurant (e.g., waiting for friends to arrive) with less than 15 min available for studying, with a medium level of concentration and high likelihood of interruption, Model 7 would apply. The learner would be given a tutorial or revision of the last exercise, with a small number of questions. The choice would depend on whether the user has already attempted exercises on that topic. This is illustrated in Fig. 5.

The first screen shows the user's context information, as given above. The second screen tells the learner the recommended interaction in order that they know what to expect, and also to allow them to make a different selection from the menu, should they so wish (i.e., the system makes individualised recommendations, but also recog-

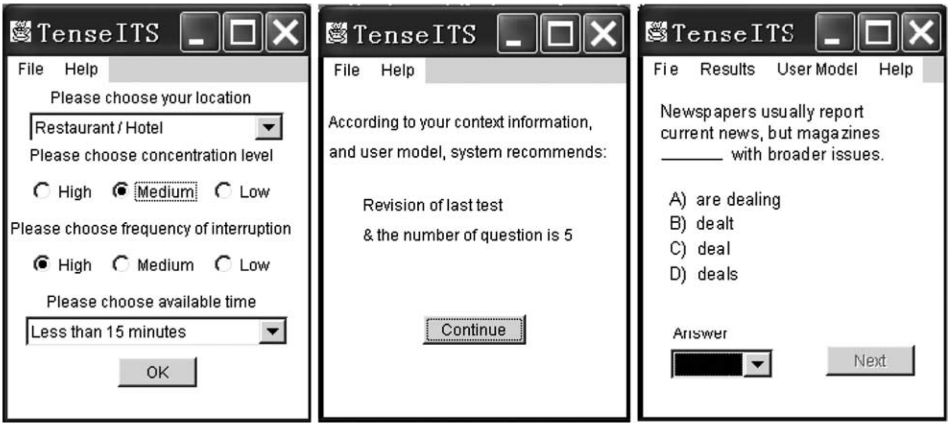

Fig. 5. Model 7: the learner at a restaurant (19:00).

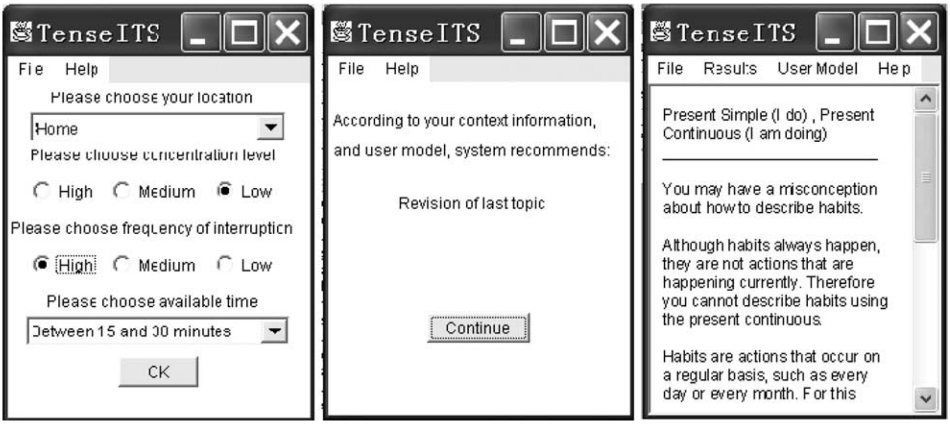

Fig. 6. Model 5: the same learner at home (22:00).

nises that the learner may sometimes wish to take control of the interaction him or herself). The final screen displays the revision questions as chosen for this learner in this location at this time. Because the learner is very likely to be interrupted (by friends arriving, or by waiters with menus or offers of drinks) and, furthermore, may not easily be able to concentrate in the restaurant environment generally, the user is offered a revision exercise: the material is not new; and the questions can be easily broken off, if necessary.

Later, should the learner again interact with TenseITS, a different interaction is likely to be recommended. For example, upon arriving home after the meal, the learner chooses to continue study for a short while before going to bed.

Fig. 6 shows that the learner is now at home, has a low level of concentration (due to tiredness), and a high likelihood of interruptions (from flatmates); and plans to study for between 15 and 30 min. Again, the contextual features are not conducive to

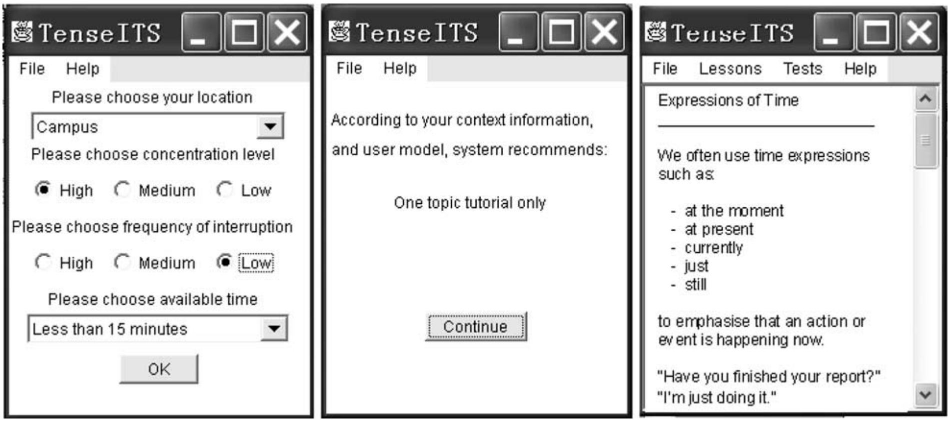

Fig. 7. Model 6: the same learner the next day on the university campus.

focussed study. Thus, the student is offered revision of a previous topic, rather than new material. This revision material includes information from the learner model, concerning misconceptions. (At a different time if the learner was not so tired, and could therefore concentrate better, and/or their flatmates were not at home – unless their learner model indicated that revision was particularly important, the learner would be more likely to be recommended new material, possibly with an associated exercise.)

The next day the learner is on the university campus. There is a very short time to fill – less than 15 min. However, the learner is able to concentrate fully, and is unlikely to be interrupted. Thus, new material is presented in an extension of previous tutorials. This is illustrated in Fig. 7.

This new material is selected according to the representations about the learner's knowledge in their learner model (i.e., different learners under the same conditions would still receive different content). However, the time the learner has available is very short, so the system provides a relatively brief description. (If the learner had more time available under these same good conditions, they may have had a longer tutorial, exercises and possibly additional revision material after the exercises, if there had been a lot of time.)

4. Discussion

We have been considering the use of a mobile intelligent language learning environment for Chinese learners of English, specifically for the use of tense. The system can be extended to other areas of English that Chinese students find difficult, for example: the use of articles. Of course, it is not only Chinese students who have such difficulties – tenses and articles can be problematic for other learners such as Russian or Arabic speakers. We can also consider implementing the system for other areas of

English or other languages. Any language or aspect of language that can be tested with multiple choice questions (because input on a handheld device is difficult), and where students commonly have difficulties, could be potentially useful. However, because there may be cultural differences and differing prominent learning strategies of different learner groups (see, e.g., Oxford, 1996), the feasibility of extending the system in different areas and for different target groups, needs to be tested.

Our initial target users are MSc students. Our approach may generalise to other masters level students, and possibly also to undergraduate students. We cannot automatically assume that the approach will also be beneficial for tourists or business people, but this can also be tested.

Future work should consider giving a finer breakdown of the time a user has available. For example, especially in the time category of 30–60 min where, in practice, interactions suitable for 35 min could be quite different from interactions for 55 min. This is particularly important given that people may choose to use the system for longer periods of time as well as for the originally intended short sessions (up to 30 min). The question of whether a learner will always know how long they have available then also becomes more important. It is likely that an additional attribute of 'sureness of time' might be relevant. Sometimes a learner might have to provide a longer possible time span if they cannot predict this exactly, and the system will then need to offer a session in which an abrupt ending at any point (or at any point within a specified range), would be feasible.

In a full ITS, local storage of a large amount of information on the handheld device could become problematic. Therefore, it is suggested that data is stored on a desktop PC, and the learner model transferred between desktop and mobile device during synchronisation. All currently potentially appropriate or relevant materials according to the learner model, will be transferred to the handheld computer when the learner synchronises the devices, and those materials no longer relevant will be deleted (see Bull and Reid, 2004; for an example).

Ultimately we would wish to consider other factors that may be relevant to the mobile language learner. This might be a more fine-grained breakdown of the attributes currently used in inferring appropriate interactions, or additional features such as whether the learner may have another period of time later in the day in which they could continue their interaction. Perhaps different material or exercises would be selected if the system could plan a series of interactions in advance, for the day.

5. Summary

This paper has introduced TenseITS, a mobile intelligent language learning environment for Chinese learners of English, that adapts the interaction according to a user's current knowledge state, their location, their ability to concentrate at that location, the likelihood that they will be interrupted, and the amount of time they have available for learning. The system is designed to help learners overcome some of the problems of language transfer, and to help them develop an explicit knowledge of features of the language, and their individual problems and misconceptions.

Examples of use were presented, and extensions discussed, to illustrate the potential of a more general implementation of our environment.

References

Becking, D., Betermieux, S., Bomsdorf, B., Feldmann, B., Heuel, E., Langer, P., Schlageter, G., 2004. Didactic profiling: supporting the mobile learner. In: World Conference on E-learning in Corporate, Government, Health and Higher Education. Association for the Advancement of Computers in Education, pp. 1760–1767.

Bedell, D.A., Oxford, R.L., 1996. Cross-cultural comparisons of language learning strategies in the People's Republic of China and other countries. In: Oxford, R.L. (Ed.), Language Learning Strategies Around the World: Cross-cultural Perspectives. Second Language Teaching and Curriculum Centre, University of Hawaii, pp. 47–60.

Bull, S., 1995. Handling native and non-native language transfer in CALL: theory and practice. In: Wakely, R., Barker, A., Frier, D., Graves, P., Suleiman, P. (Eds.), Language Teaching and Learning in Higher Education: Issues and Perspectives. CILT, London, pp. 97–108.

Bull, S., 2003. User modelling and mobile learning. In: Brusilovsky, P., Corbett, A., de Rosis, F. (Eds.), User Modeling 2003: 9th International Conference. Springer-Verlag, Berlin Heidelberg, pp. 383–387.

Bull, S., McEvoy, A.T., 2003. An intelligent learning environment with an open learner model for the desktop PC and pocket PC. In: Hoppe, U., Verdejo, F., kay, J. (Eds.), Artificial Intelligence in Education. IOS Press, Amsterdam, pp. 389–391.

Bull, S., Reid, E., 2004. Individualised revision material for use on a handheld computer. In: Attewell, J., Savill-Smith, C. (Eds.), Learning with Mobile Devices. Learning and Skills Development Agency, London, pp. 35–42.

Catt, M., Hirst, G., 1990. An intelligent CALI system for grammatical error diagnosis. CALL 3, 3–26.

Chang, J., 1987. Chinese speakers. In: Swan, M., Smith, B. (Eds.), Learner English. Cambridge University Press, Cambridge, pp. 224–237.

Dalgish, G.M., 1984. Computer-assisted ESL research. CALICO Journal 2 (2), 32–37.

Dey, A.K., Abowd, G.D., 1999. Towards a better understanding of context and context-awareness, GVU Technical Report GIT-GVU-99-22, College of Computing, Georgia Institute of Technology.

ECTACO Learning software, not dated. Language learning software for pocket PC. Available from: <www.ectaco.ca/catalogue/Language-Learning-Software-for-Pocket-PC-items>.

Jameson, A., 2001. Modelling both the context and the user. Personal Technologies 5 (1), 1–4.

Ketamo, H., 2002. MLearning for kindergarten's mathematics teaching. In: Milrad, M., Hoppe, U.Kinshuk, (Eds.), Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education. IEEE Computer Society, pp. 167–168.

Lehman, R., Conceicao, S., 2003. Transferring/applying Learning Objects in Various Delivery Formats:, Step by Step, 19th Annual Conference on Distance Teaching and Learning. University of Wisconsin.

Malliou, E., Stavros, S., Sotiriou, S.A., Miliarakis, A., Stratakis, M., 2002. The AD-HOC project: e learning anywhere, anytime. In: Anastopoulou, S., Sharples, M., Vavoula, G. (Eds.), Proceedings of the European Workshop on Mobile and Contextual Learning. University of Birmingham, pp. 47–50.

Odlin, T., 1989. Language Transfer, Cross-linguistic Influence in Language Learning. Cambridge University Press, Cambridge.

Ogata, H., Yano, Y., 2004. Context-aware support for computer-supported ubiquitous learning. In: Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education. IEEE Computer Society, pp. 27–34.

O'Malley, J.M., Chamot, A.U., 1990. Learning Strategies in Second Language Acquisition. Cambridge University Press, Cambridge.

Oxford, R., 1990. Language Learning Strategies, What Every Teacher Should Know. Heinle and Heinle Publishers, Boston, Massachusetts.

Oxford, R.L. (Ed.), 1996. Language Learning Strategies Around the World: Cross-cultural Perspectives. Second Language Teaching and Curriculum Centre, University of Hawaii.

Rutherford, W.E., Sharwood Smith, M., 1985. Consciousness-raising and universal grammar. Applied Linguistics 6 (3), 274–282.
Schmidt, R.W., 1990. The role of consciousness in second language learning. Applied Linguistics 11 (2), 129–158.
Schuster, E., 1986. The role of native grammars in correcting errors in second language learning. Computational Intelligence 2, 93–98.
Schwind, C.B., 1990. An intelligent language tutoring system. International Journal of Man–Machine Studies 33, 557–579.
Sharples, M., 2000. The design of personal mobile technologies for lifelong learning. Computers and Education 34, 177–193.
Wang, Y., Garigliano, R., 1995. Empirical studies and intelligent language tutoring. Instructional Science 23 (1-3), 47–64.
Weischedel, R.M., Voge, W.M., James, M., 1978. An artificial intelligence approach to language instruction. Artificial Intelligence 10, 225–240.
Zancanaro, M., Stock, O., Alfaro, I., 2003. Mobile cinematic presentations in a museum guide. In: Attewell, J., Da Bormida, G., Sharples, M., Savill-Smith, C. (Eds.), MLEARN 2003: Book of Abstracts. Learning and Skills Development Agency, London, pp. 76–77.
Zimmerman, A., Lorenz, A., Specht, M., 2003. User modeling in adaptive audio-augmented museum environments. In: Corbett, A., de Rosis, F. (Eds.), User Modeling 2003: 9th International Conference. Springer-Verlag, Berlin Heidelberg, pp. 403–407.